Issued February 8, 1908.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—Circular 139.
GIFFORD PINCHOT, Forester.

A PRIMER OF WOOD PRESERVATION.

By

W. F. SHERFESEE,
FOREST ASSISTANT.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1908

CONTENTS.

	Page.
What wood preservation means	3
What decay is	4
How decay can be retarded	5
By seasoning	5
By chemical impregnation	6
Preservatives and processes in the United States	7
Creosote and zinc chlorid	7
The pressure processes	8
The open-tank process	8
The brush method	9
The effect of treatment on the strength of timber	9
The tendency of wood preservation in the United States	11
The saving in dollars and cents	12
What wood preservation can do in the future	13

A PRIMER OF WOOD PRESERVATION.

WHAT WOOD PRESERVATION MEANS.

The cost of wood is to-day a big item to every farmer, every railroad manager, every mine owner—to everyone, in fact, who must use timber where it is likely to decay. How to reduce the expense of fence posts, railroad ties, mine timbers, telegraph poles, and other timbers which must constantly be replaced has become a vital problem. The kinds of timber used for these purposes are becoming scarcer and scarcer and their prices higher and higher. Long misuse of the forest has brought its sure result. Even with the most efficient management it would be a long time before the supply of the best timbers would increase in quantity or decrease in price.

There are two ways in which the situation may be met. One is to prolong the life of the forest by wise use; the other is to prolong the life of timbers in service by treating them with some preservative. It is the second of these methods of economy which is the subject of this circular.

It is easy to see that if the length of time timbers can be used is doubled, only half as much timber will be required as before and only one-half as much money will need to be spent in the purchase of timber. This is the chief gain in treating wood with preservatives. Yet there is another and important one. Many woods, which for a long time were considered almost worthless, can be treated and made to last as long as the scarcer and more expensive kinds. This of course means that the consumer will have the choice of a much greater number of woods than he had before and at less cost.

Wood preservation, then, prolongs the life of timbers in use, reduces their cost, and gives to the user a wider choice of woods than ever before.

Methods of preservation must be varied for different localities and different kinds of wood, and the Forest Service has issued several publications which deal with the problems presented in different regions. These publications and detailed information can be had upon application to the Forester.

WHAT DECAY IS.

The decay of a plant body, such as wood, is not an inorganic process like the rusting of iron or the crumbling of stone, but is due to the activities of low forms of plant life called bacteria and fungi. Bacteria are among the simplest of all forms of life, often consisting of but a single cell, microscopic in size. Sometimes several such cells may be attached to each other, and so form a thread or filament. Usually they are colorless, and multiply by the division of the parent cell into other cells, which, in turn, divide again.

Fungi, although much more complicated than bacteria, are also low in the scale of creation when compared with familiar flowering plants and shrubs. They consist merely of tiny threads or hyphæ, which are collectively known as the mycelium. In many of the higher forms of fungi the threads grow together to form compact masses of tissue. Familiar examples of these forms are the toadstools, which grow on damp, rotting logs, and the "punks," or "brackets," on the trunks of trees in the forest.

The causes of decay in wood, however, are not these fruiting bodies themselves. Spores, very primitive substitutes for seed, which are borne in the countless compartments into which the under surfaces of the fruiting bodies are sometimes divided, are produced in infinite number, and are so fine that they can be distinguished only by the microscope. When seen in bulk they appear as the finest dust. Like dust, they are carried by the wind and strike all portions of the surrounding objects. Few species of fungi successfully attack healthy living trees, and only a comparatively small number can attack and destroy wood. Yet the spores of some find a lodging in dead portions of a tree or in cut timber, and, if the wood is moist and in the right condition for the spore to grow, it germinates and sends out a thin, filmlike white thread, which, by repeated branching, penetrates the entire structure of the wood. These are the real agents of decay.

This is not the only way that a fungus can enter a sound stick of timber; for if a good stick is lying close to a rotting one, the mycelium may grow over or through the moist ground and so reach the sound stick, which it immediately attacks. Sometimes, too, when a tree is cut it already has a fungus growing in its wood. If the fungus happens to be a true parasite—that is, if it can grow only in living tissues—it will die when the tree is felled; but if it has been accustomed to growing in the heartwood of the tree, which is practically dead, it may continue to live and develop even after the tree has been sawed into timber.

Wood is composed of minute cells. The chief material of the cell-walls is a substance called cellulose, and around this there are in-

crusted many different organic substances known collectively as lignin. Most of the wood-destroying fungi attack only the lignin; others attack the cellulose alone, while a third class destroy all parts of the wood structure. The lignin and the cellulose are dissolved by certain substances secreted in the fungi, and thus serve as food for the fungus growth. In this way the fungi can develop until they extend throughout every portion of the timber. After a time the amount of fiber changed into food and assimilated by the fungus causes the wood to become discolored. Discoloration may also be produced by pigments in the fungus or secreted by it. Finally so much of the wood fiber is eaten away or changed in composition that its strength is greatly diminished, the texture becomes brittle and disconnected, and the wood is said to be "rotten."

But food is not the only thing that a fungus requires for its growth and development. It must also have heat, air, and moisture. If any one of these is lacking the fungus can not develop. The necessary heat is supplied by almost every climate, and it is only in rare cases, as under water or deep under the surface of the ground, that air can be excluded from the timber. Of the four requirements, therefore, two are beyond control. It is only by depriving the fungi of food or moisture that the destruction they cause can be prevented.

HOW DECAY CAN BE RETARDED.

BY SEASONING.

The simplest way of prolonging the life of timber exposed to the attack of wood-destroying fungi is to reduce the moisture content of the wood. The amount of water in green timber varies according to the part of the tree from which the wood is cut. The outer layers of the trunk are composed of sapwood, the cells of which contain large amounts of organic substances which serve excellently as food for the fungi. Moreover, sapwood always contains a large amount of water. It is the portion of the tree, therefore, most susceptible to attacks from fungi. Heartwood, which can usually be distinguished from sapwood by its darker or more reddish color, contains, on the other hand, much less moisture. It is therefore more durable than sapwood. But because its pores are stopped up by gums and resins it dries out much less rapidly than the more porous sapwood. In almost every case as much care should be taken thoroughly to dry out the heartwood as in the case of the moister sapwood.

By piling the timber so as to permit free access of air all around it the moisture content of timbers of certain sizes can be reduced to about 15 or 18 per cent. Of course the climate has a great influence on the rate at which the wood dries out and the total amount of moisture it loses.

The moisture content of air-dry wood can be still further reduced by kiln-drying; and this is employed to a considerable extent, but usually for other purposes than increasing the durability of the wood. Moreover, either air-dry or kiln-dry wood has the power to reabsorb moisture when exposed to the atmosphere in damp situations, and so the benefits of drying, as far as durability is concerned, are only moderate. Yet the increased life which it gives is, in nearly all cases, more than sufficient to repay the added cost of seasoning.

The strength of partially seasoned timber, other things being equal, increases as the amount of moisture it contains decreases. Thoroughly seasoned timber of small sizes is sometimes three or even four times as strong as the same timber, when green. Moreover, during the process of drying out, important but little understood changes take place in the organic contents of the wood cells, by which the wood is not only rendered less attractive to fungi, but is made more permeable and so better prepared for preservative treatment. All timber should be thoroughly seasoned before being exposed to decay.

An exterior coating secured by dipping a post in a thin solution of cement or other material that will harden on the post is not an effective protection, because in shrinking or swelling the wood forms cracks through which decay enters.

BY CHEMICAL IMPREGNATION.

By far the best method of checking the growth of fungi, however, is to deprive them of food. This can be done by injecting poisonous substances into the timber, and so changing the organic matter from foods suitable for fungi into powerful fungicides. It is a mistake to suppose that the germs of decay are inherent in the wood, and only need an opportunity for development to bring about its destruction. Several processes for the preservation of wood have been founded on the false assumption that it is necessary to destroy the "germs" in the interior of the timber. The impression doubtless arose from the fact that, after a stick of timber begins to rot, it is impossible to tell just where the fungus spores germinated and gained entrance into the timber. Moreover, the fact that the interior of the wood may have reached an advanced stage of decay before there are any external evidences of the fungi—such as fruiting bodies, or films of mycelium—tends to convince the casual observer that decay starts from the interior. Yet the wood-destroying agencies start from the outside. This explains the efficacy of certain paints which merely form a superficial coating over the surface of the timber, but which are poisonous enough to prevent the spores from germinating, or the hyphæ of most forms of wood-destroying fungi from penetrating into the unprotected wood in the interior. The ancients were in the

habit of painting their statues with oily and bituminous preparations to preserve them from decay. The great wooden statue of Diana at Ephesus, which was supposed to have descended miraculously from heaven, was protected from earthly decay by oil of nard. Pettigrew extracted the preservative fluids from the heart of an Egyptian mummy that had resisted decay for over 3,000 years, and found that decomposition immediately set in. This showed that it was the presence of the antiseptics which prevented decay, and not a chemical change of the tissues.

PRESERVATIVES AND PROCESSES IN THE UNITED STATES.

Of the many antiseptics which have been proposed for the preservation of timber only four have been largely used with success in the United States. These are creosote, zinc chlorid, corrosive sublimate (bichlorid of mercury), and copper sulphate. At the present time copper sulphate has fallen into almost total disuse, and corrosive sublimate is restricted to two plants in New England. The use of this latter is the so-called "kyanizing" process which is so frequently referred to in all the literature of wood preservation. In general, the process consists in steeping the timber in a dilute solution of corrosive sublimate long enough to insure thorough penetration.

CREOSOTE AND ZINC CHLORID.

Thus in the United States creosote and zinc chlorid are the only preservatives in common use. There are many other patented substances known by various names; but most of them have for their base one or the other of these two preservatives. Creosote is a by-product of coal tar, which is produced at most plants for the manufacture of illuminating gas and at by-product coke-oven plants. This tar is distilled, and during the process the condensed vapors are run into three separate vessels and thus separated into the light oils of coal tar or naphthas, the dead oil of coal tar or creosote, and pitch. Creosote is not a simple substance like zinc chlorid. On the contrary, it contains a large number of constituents of great chemical complexity.

Wood tar, when distilled in a similar manner, gives "wood creosote," which like that derived from coal tar, possesses strong antiseptic properties. There is also on the market a so-called creosote, a by-product of water-gas tar or tar manufactured from kerosene oils, which for wood preservation is probably inferior to the true creosote. In general, however by "creosote" is meant the dead oil of coal tar.

Zinc chlorid is obtained by dissolving metallic zinc in hydrochloric acid. This is further diluted by water before it is used for wood preservation.

Just as there are two preservatives in common use, so there are two principal methods of injecting them into the timber. These may be called the "pressure-cylinder method" and the "open-tank method." A third process, known as the "brush method," is used to a more limited extent.

THE PRESSURE PROCESSES.

Up to very recent times the pressure-cylinder method was used almost exclusively in the United States. With creosote it is known as the Bethell process, and with zinc chlorid the name of Burnettizing is applied. The timber to be treated is placed on iron trucks or "cylinder buggies" and drawn by steel cables into huge horizontal cylinders, some of which are 8 or even 9 feet in diameter and more than 150 feet long. These are capable of withstanding high pressure, and their doors are so arranged that, after the timber is drawn in, they can be closed and hermetically sealed. It is the common practice in this country—a practice which long experience in Europe, as well as in America, has proved to be unwise—to treat the timber before it has had time to dry out in the open air. The following is the usual method. After the doors are closed live steam is admitted into the cylinder, and a pressure of about 20 pounds per square inch is maintained for several hours, the exact time depending upon the individual opinion of the operator, as well as upon the moisture content and size of the timber under treatment. In some cases the steam pressure is allowed to go considerably above 20 pounds, but there is constant risk of injuring the strength of the timber. When the steam is at last blown out of the cylinder, the vacuum pumps are started and as much of the air as possible is exhausted from the cylinder and from the wood structure. This process also continues for several hours. Finally, after the completion of the vacuum period, the preservative is run into the cylinder and the pressure pumps are started and continued until the desired amount of preservative fluid is forced into the wood. The surplus preservative is then blown back into the storage tanks, the timber is allowed to drip for a few minutes, and finally the cylinder doors are opened and the treated timber is withdrawn.

THE OPEN-TANK PROCESS.

The injection of the preservative by the open-tank process depends upon a different principle.[a] The wood is first thoroughly seasoned, and much of the moisture in the cells and intercellular spaces is replaced by air. If the timber is peeled soon after cutting, and

[a] See Forest Service Circular 101, The Open-Tank Method for the Treatment of Timber.

stacked in open piles, the time required for seasoning can be greatly lessened. The seasoned timber, or that portion of it which is to be preserved, is immersed in a hot bath of the preservative contained in an open iron tank. This hot bath is continued for from one to five or six hours, depending upon the timber. During this portion of the treatment the air and moisture in the wood expand and a portion of them pass out, appearing as little bubbles on the surface of the fluid. At the end of the hot bath, as quick a change as possible is made from the hot to a cold preservative. This causes a contraction of the air and moisture remaining in the wood, and, since a portion of it had been expelled, a partial vacuum is created which can be destroyed only by the entrance of the preservative. Thus atmospheric pressure accomplishes that for which artificial pressure is needed in most of the commercial plants. Whether the open-tank or pressure-cylinder method is the more desirable depends upon the particular conditions of each case. Both methods have their particular uses and neither can always be wholly substituted for the other.

THE BRUSH METHOD.

A less efficient but cheaper treatment can be secured by painting the surface of the timber with at least two coats of hot creosote or some similar preservative.[a] The liquid may be applied with an ordinary paint brush, but care should be taken to fill thoroughly with the preservative all checks, knot holes, and similar defects. The liquid can penetrate only a very short distance into the wood, but as long as there remains an unbroken antiseptic zone around the surface, the spores of the wood destroying fungi can not enter. It is especially important in this method that the timber should be thoroughly air-dry before treatment. Otherwise the evaporation of water from the interior of the stick will cause checks to open up and so expose the unprotected wood to fungous attack.

This process finds its principal use where the amount of timber to be treated is too small to justify the erection of even a small treating plant; where the land is so rugged, as in the building of mountain telephone lines, that it is impracticable to transport the timber for even short distances, or where it is necessary to restrict the cost of the treatment to the lowest possible figure.

THE EFFECT OF TREATMENT ON THE STRENGTH OF TIMBER.

The question is frequently asked whether or not the strength of timber is impaired by the processes in common use for wood preservation. No general answer to this can be given, since it depends alto-

[a] See Forest Service Circular 104, Brush and Tank Pole Treatments.

gether upon the character and strength of the preservative and the care with which it is injected. It is probable that creosote does not penetrate the wood fibers, but merely forms an external coating around them; hence, in itself, it can not appreciably affect the strength of the timber. In general the ultimate strength of treated timber depends, first, upon the percentage of moisture remaining in the wood; and, second, upon whether or not the wood has been subjected to injuriously high temperatures during the preliminary processes of steaming and vacuum, if these processes were employed. The degree of temperature which can be applied without risk of serious injury depends upon the duration of the temperature, the moisture content and quality of the wood, and upon the pressure to which it is subjected.[a]

If proper care is observed in the treatment of the timber all danger of injury from excessive temperatures can be avoided. The amount of moisture remaining in the wood is therefore a point of greater importance. As the moisture in a piece of wood is reduced by drying, the strength of the wood increases, and as moisture is subsequently reabsorbed, the strength up to a certain limit is again reduced. Creosote retards both the absorption and evaporation of water; hence its presence in thoroughly seasoned wood exposed to humid conditions tends to conserve its strength, whereas, on the other hand, if it is applied to green wood the strengthening action of water-evaporation is retarded. Some processes tend to increase the moisture content of the wood and others to diminish it. Therefore, whether the strength of timber is increased or decreased during creosoting depends chiefly upon the process employed.[b]

The effect which live steam at safe temperatures has upon the moisture content of wood is now being made the subject of a special study. It is safe to say, however, that during steaming the amount of moisture in air-dry timber is increased, with a consequent decrease in strength, and that the succeeding vacuum fails to remove all of the added moisture before the introduction of the preservative. With many kinds of air-dry timber, however, the steaming can be dispensed with altogether, and this is done in many commercial plants. Whether or not it can be omitted with all kinds of wood is not yet certain.

These considerations, of course, do not apply to the open-tank method, or to similar processes where the timber is immersed

[a] Detailed discussions of these points will be found in Forest Service Circulars Nos. 39 and 108.

[b] A discussion of the moisture content of creosoted wood may be found in Forest Service Circular 134, The Estimation of Moisture in Creosoted Wood.

directly in the hot preservative, without the preliminary steaming and vacuum. Immersion in hot oil tends to evaporate some of the moisture in the wood and so to increase its strength.

Zinc chlorid and the other preservatives which are in water solution have a wholly different effect. Unless the wood structure is already filled with moisture to the point of saturation, more water is injected into it with the preservative, with the result, if the wood is partially seasoned, of decreasing its strength. The original strength may be regained, however, by seasoning. If the zinc chlorid is injected into the timber in too concentrated a solution it may cause a chemical dissolution of portions of the wood fiber, with the result of permanently decreasing the strength of the timber. But for the solutions in common use this danger need not be taken into consideration.

Both creosote and zinc chlorid are excellent antiseptics, and both can be obtained in large quantities. Creosote's principal point of superiority, however, lies in its insolubility in water. Hence, once it is injected into timber it will not wash out, no matter how wet may be the situation in which the treated timber is placed. On the other hand, zinc chlorid is much cheaper than creosote, and since it is shipped in the form of a solid the freight charges are considerably less than they would be for enough creosote to treat the same amount of timber. But zinc chlorid is soluble in water, being in fact injected into the timber in water solution, and so when timber treated with zinc chlorid is exposed to moisture the leaching out of the salt is only a question of time. Hence, zinc chlorid is most commonly used in comparatively dry situations. Creosote, on the other hand, is used where the timber will be subjected to moisture. Moreover, creosote is one of the very few preservatives within commercial reach which offer absolute protection against the marine borers, which work such havoc among the wharves of the Atlantic, Gulf, and Pacific coasts. Since it is insoluble in water it can not wash out of the piles into which it has been properly injected, and since it is more than a mere external coating there is no danger of its being broken off by floating débris.[a]

THE TENDENCY OF WOOD PRESERVATION IN THE UNITED STATES.

In the United States the tendency in wood preservation is to modify the processes rather than to change the preservatives. At present, creosote and zinc chlorid, pure or in mixture, are the only preservatives which are in general use. A constant effort is being made to overcome the chief drawbacks to the use of each of these.

[a] A more detailed discussion of this may be found in Forest Service Circular 128, Preservation of Piling Against Marine Wood Borers.

Processes have been developed which involve the compression and expansion of the air in the wood structure to expel some of the expensive creosote, leaving only a film along the cell walls. The amount of oil left in the timber is reduced, and in consequence the cost of the treatment as well. In other cases zinc chlorid and creosote are mixed together and injected into the timber in the form of an emulsion, the object being to reduce the cost of the treatment and to prevent the zinc chlorid from leaching out of the timber. Sometimes the timber is impregnated with zinc chlorid, and only a narrow outer layer is filled with creosote; or again, glue and tannin are employed in the effort to plug up the outer wood cells and so keep the salt in the interior.

THE SAVING IN DOLLARS AND CENTS.

No process to preserve timber can come into use unless it is certain that the outlay for the treatment will be more than offset by the longer service of the treated timber. It is difficult to give a general example of the saving effected by treating certain timbers with preservatives, since it depends so largely upon local conditions and the class of timber. The following examples of the saving which under certain circumstances can be effected by proper preservative treatment are, however, typical, although they may not apply to other localities and to other kinds of timber without some modification:

An untreated loblolly pine fence post costs about 8 cents, or, including the cost of setting, 14 cents. Its length of life in this condition is about two years. Compounding interest at 5 per cent, the annual charge on such a post is 7.53 cents—that is, it costs 7.53 cents a year to keep such a post in service. If given a preservative treatment, which costs about 10 cents, the length of life of the post is increased to about eighteen years. The total cost of such a post, set, is then 24 cents, which, compounded at the above interest rate, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

The saving due to treating railroad ties is also worthy of consideration. A loblolly pine tie untreated is worth about 30 cents, and its length of life in this condition is about five years. To this first cost should be added the cost of laying, which is about 20 cents. The annual charge figured as above is then 11.52 cents. If treated it will last for about twelve years. Its cost of treatment is about 35 cents. A treated tie in the track, therefore, costs about 85 cents. Compounded at 5 per cent, as in the above example, its annual charge is 9.48 cents. The saving per year is therefore 2.04 cents per tie. Assuming 2,880

ties per mile of track, the saving due to treatment alone amounts to $58.75 per mile, which corresponds to an investment of $1,175 per mile.

Assuming that the cost of an untreated oldfield or loblolly pine pole, including hauling and setting, is $5, and that it lasts five years—a fair estimate for many portions of the United States—the annual charge, compounding interest at 5 per cent, amounts to $1.15. In other words, it costs the owner $1.15 a year for every such pole in his lines. This corresponds to a capital of $23 invested at 5 per cent interest, or, for a mile of 40 poles, to $920. Again, assuming that the butt of such a pole can be treated for $1, the first cost of the pole, set in the ground, is $6. The treatment may reasonably be expected to secure a service from the pole of twenty years, instead of five years when untreated. Thus, the annual charge on the treated pole, with the same rate of compound interest, is only $0.48 per pole, which corresponds to an investment of $9.60; or $384 per mile, as compared with the $920 per mile in the other case. Thus during the life of the treated pole a yearly saving of the interest on $536 will be effected for every mile of line.

It might be said that it is not positively proved that the treated poles will last twenty years, and that it will be necessary to wait until the poles are finally removed before the length of their service can be determined. A sufficient answer to this argument is that treated poles need to last only 1.6 years longer than untreated poles in order to justify the cost of treatment. Moreover, there is abundant evidence to show the long life of creosoted wood.[a] Even in this country there are many examples of poles and other timbers creosoted twenty and even thirty years ago, which to-day are apparently as sound as when first set in the ground. In Europe, where wood preservation is an older industry, the results are still more marked. There have been failures, but in every instance they can be traced to incompetent or fraudulent work, insufficient impregnation, improper preparation of the timber, or some similar cause.

WHAT WOOD PRESERVATION CAN DO IN THE FUTURE.

At the present rate of consumption the exhaustion of the supply of structural timbers in the United States is a thing of the very near future. Moreover, the cost of fence posts is an ever-increasing burden upon the farmer and stockman. In the case of structural timbers telephone poles will serve as an example. Statistics gathered by the Forest Service show that in 1906 more than 3,500,000 telephone and telegraph poles were cut. This includes only poles 20 feet and over in length, and ignores the far greater number of poles and posts of

[a] See Forest Service Circular 98.—Quantity and character of creosote in well-preserved timbers.

smaller sizes. Of the poles cut, at least 40 per cent, or nearly 1,500,000, were either of white cedar or of arborvitæ.

Under average forest conditions it requires more than one hundred and ninety years [a] to grow a 30-foot cedar pole. The average life of such a pole, when set in the ground in its natural state, does not exceed fifteen years. In other words, in order to meet even the present annual consumption there must be nearly thirteen trees growing in the forest for every 30-foot cedar pole standing to-day. A study of the rates of growth and the durability of other kinds of wood used for other purposes—ties, mine props, piling, etc.—shows that the consumption of structural timber greatly exceeds its production. Yet relief can be had in prolonging the length of service of the timber now being placed in position. Most of the cross-ties placed in the track to-day must be renewed within eight years. But if their life can be lengthened to fifteen years the benefits of the preservative treatments are plain. It is estimated that 150,000 acres are required each year to grow timber for the anthracite coal mines alone. The average life of an untreated mine prop is not more than three years. By proper preservative treatment it can be prolonged by many times this figure. Poles which in ten or twelve years, or even less, decay so badly at the ground line that they have to be removed can, by a simple treatment of their butts, be made to last twenty or twenty-five years. The same is true of fence posts and other timbers exposed to direct contact with the soil. Sap shingles, which are almost valueless in their natural state, can be easily treated and made to outlast even painted shingles of the most decay-resistant woods. Thousands of dollars are lost every year by the so-called "bluing" of freshly sawed sapwood lumber. This can often be prevented by proper treatment and at a cost so small as to put the method within the reach of the smallest operator. Millions of feet of insect and fire-killed timber in the West are standing untouched in the forest. Under present conditions this timber is not only useless, but is an actual detriment to the forest. Much of this dead wood possesses all the requirements of high-grade structural timber, with the single exception of durability. Often where dead timber is most abundant there is an almost complete absence of the naturally durable kinds of wood, and timber for structural purposes—ties, mine timbers, poles, posts, etc.—must be transported long distances at heavy expense. The thorough seasoning of several years has strengthened the dead wood and put it in an excellent condition for treatment. Fortunately, most of it is of a kind which readily absorbs the liquid preservatives, and so is well adapted to successful impregnation. Therefore, expensive

[b] True for arborvitæ or white cedar in Michigan swamps. Western red cedar,
[a] True for arborvitæ or white cedar in Michigan swamps. Western red cedar,

pressure plants are, in most cases, unnecessary, and the cost of erecting and operating a small open-tank treating plant is surprisingly low. In the South the cheap and abundant loblolly pine, one of the easiest of all woods to treat, can by proper preparation be made to take the place of the high-grade longleaf pine for many purposes. Black and tupelo gums and other little-used woods have a new and increasing importance because of the possibility of preserving them from decay at small cost. In the Northeastern and Lake States are tamarack, hemlock, beech, birch, and maple, and the red and black oaks, all of which by proper treatment may help to replace the fast-diminishing white oak and cedar. In the States of the Mississippi Valley the pressing fence-post problem may be greatly relieved by treating such species as cottonwood, willow, and elm.

Approved.

JAMES WILSON, *Secretary.*

WASHINGTON, D. C., *December 4, 1907.*

OTHER PUBLICATIONS OF THE FOREST SERVICE WHICH DEAL WITH WOOD PRESERVATION.

Bulletin 10. Timber: An Elementary Discussion of the Characteristics and Properties of Wood. (Securable only by purchase from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 10 cents.)

Bulletin 41. Seasoning of Timber.

Bulletin 50. Cross-Tie Forms and Rail Fastenings, with Special Reference to Treated Timbers.

Bulletin 51. Report on the Condition of Treated Timbers Laid in Texas, February, 1902.

Circular 39. Experiments on the Strength of Treated Timber.

Circular 80. Fractional Distillation of Coal-Tar Creosote.

Circular 98. Quantity and Character of Creosote in Well-Preserved Timbers.

Circular 101. The Open-Tank Method for the Treatment of Timber.

Circular 103. Seasoning of Telephone and Telegraph Poles.

Circular 104. Brush and Tank Pole Treatments.

Circular 108. Strength of Wood as Influenced by Moisture.

Circular 111. Prolonging the Life of Mine Timbers.

Circular 112. The Analysis and Grading of Creosotes.

Circular 117. The Preservative Treatment of Fence Posts.

Circular 128. Preservation of Piling Against Marine Wood Borers.

Circular 132. The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties.

Circular 134. Estimation of Moisture in Creosoted Wood.

Circular 136. Seasoning and Preservative Treatment of Aborvitæ Poles.

Circular 141. Wood Paving.

Extract 395 from the Yearbook of the Department of Agriculture (1905); Prolonging the Life of Telephone Poles.